DOCUMENT RESUME

ED 031 425 SP 002 858

By-Clark, Michal C.; Merrill, M. David
A Cybernetic Modification Scheme for an Instructional System.
Pub Date 6 Feb 69
Note-14p.; Paper presented to the national convention of the American Educational Research Association, Los Angeles, California, February 6, 1969.
EDRS Price MF-$0.25 HC-$0.80
Descriptors-Academic Aptitude, Computer Assisted Instruction, *Individualized Instruction, Instructional Design, *Models

A cybernetic subcomponent is proposed which can gather the necessary information and make the operating decisions to allow one system of instruction (M.D. Merrill's) to respond to and provide for differential needs within the individual learner. (Merrill's system divides the universe of instructional objectives into a taxonomy of seven categories, each having associated with it a paradigm for instruction of its objectives.) A model modification scheme for computer-assisted instruction is proposed for introducing and using information on individual learner aptitudes that allows the system to provide individually prescribed instruction. Aptitudes have associated with them value scales so that the value of a learner's aptitude will be associated with a value of a parameter for one of the instructional paradigms. (Each paradigm has more than 50 parameters associated with it.) Parameter values (scaled from 0 to 1.0) for a given individual are always changing, being reset after every learner response. The model monitors performance and changes parameter values, resulting in changes in the content, organization, and sequencing of instructional displays. Before the modification schedule can be incorporated into an instructional system and implemented for use, relevant parameters must be identified and scaled; experiments must be run to validate the scheme. Collection of computer-generated data for demonstration of the system is currently in the planning stages. (JS)

A CYBERNETIC MODIFICATION SCHEME FOR AN INSTRUCTIONAL SYSTEM

Michal C. Clark
University of Texas
Austin, Texas

and

M. David Merrill
Brigham Young University
Provo, Utah

Presented to:

American Educational Research Association
National Convention
Los Angeles, California

February 6, 1969

Cronbach has said that it is the task of the psychologist to devise or select instructional methods that will interact with differences in learners so that the achievement of all pupils working toward a given educational objective will be significantly greater than what it would be if only a single "best" method of instruction were used. In order to carry out this task, a consideration of individual differences must be included in any instructional systems.

Various instructional systems have recognized the need to prescribe instruction as a function of individual learner demands. However, most of these systems have only left a receptacle into which some sort of a cybernetic sub-system can later be plugged. This paper proposes a workable, cybernetic subcomponent which can gather the necessary information and make the operating decisions to allow one system of instruction to respond to and provide for differential needs within the individual ~~learners~~ learners. Merrill's system of instruction is the one to be examined here.

The instructional system divides the universe of instructional objectives into a taxonomy of seven categories. Any specifiable instructional objective can be put into one of the categories. Each category has associated with it a paradigm for instruction of its objectives. To use the system, the teacher or instructional designer develops (or takes) a set of curricular or course objectives, classifies them and then prescribes an instructional paradigm as a function of the classification. It must be noted that these paradigms are general strategies and allow for many optional parameter settings to be considered before actual instructional displays are selected and presented.

Individual difference information can be put into the system by considering the learner's aptitudes. Here, aptitude is used as Cronbach (1967, P. 24) has used the term, "...Aptitude, pragmatically, includes whatever promotes the pupil's survival in a particular educational environment, and it may have as much to do with styles of thought and personality variables as with the abilities covered in conventional tests". That is, the learner's aptitude can determine what he learns, how he learns and the rate at which he learns. The instructional situation presents various "objects of knowledge" as stimuli to be learned. It is the interaction of the learner and his aptitudes with the instructional environment and its stimulus materials which will determine what is learned--how the learner's aptitudes have changed and how he will perform.

The individual difference information can be put into the system as information about the learner's aptitudes. Then, the general instructional paradigm can be prescribed as a function of classification of objectives, and the parameters of the paradigm can be set as a function of the individual's aptitudes. So, the instructional displays received by an individual learner are determined by the objectives of the course and his own aptitudes. The remainder of this paper presents a model to allow the necessary aptitude information to be collected and utilized by the instructional system in order to provide individually prescribed instruction. (It is only fair to warn the reader that this model was derived while thinking of specific application of the implementation of Merrill's system on a CAI system).

Only those aptitudes which can be utilized as parameters of the seven instructional paradigms may be used in the system at this time. In general, the aptitudes must have associated with them either continuous value scales or discrete scales with specifiable values before they can be used by the system. Then, the value of the learner's aptitude will be associated with a value or a parameter for one of the instructional paradigms. An example of a parameter would be amount of reinforcement; the value of that parameter would be a certain amount of reinforcement. In essence, the aptitude information allows the general instructional paradigm to be modified to meet the specific needs of the individual learner. Hence, the model for introducing and using aptitude information within the system is called the modification scheme.

The modification scheme allows all of the micro-decisions necessary for implementing the instructional system to be made. It provides an economical way to gather and utilize the vast amounts of data necessary to individualize instruction for a large number of students.

In order to understand the following intuitive derivation, it is necessary to remember that the content of instructional displays and sequence of displays received by a learner is governed by the values of the parameters with the instructional paradigm appropriate to the objective under consideration. Then, by changing the parameter values, different displays would result.

The modification scheme allows the parameter values to be set differently for each individual in accordance with his own aptitudes. It also allows the parameter values to change as the individual's aptitudes (interests, acquired knowledge, etc) change. Hence, the modification scheme provides a dynamic process for utilizing aptitude information.

The system requires that parameter values all be scaled from 0 to 1.0. Discrete variables fall into the same range with limens between values determined by mapping the corresponding aptitude scale into this restricted parameter scale. Parameter values can be initialized in any way (e.g. randomly or at group means, etc.).

Once the system begins to operate, parameter values for a given individual are always changing. After every learner response, parameter values are reset. The operators used to change parameter values are given in Table 1. Operator A will result in the parameter value to be increased. Operator B will decrease the parameter value. After every response, one of the operators will be applied.

The selection of the operator to be applied is made independently for each parameter. The selection is according to a "win-stay; lose-shift" strategy. Either operator may be applied after the first learner response. From then on, the selection of the operator is determined by the operator used previously <u>and</u> by the correctness of the previous response. After a correct response, the same operator is to be used as was used on the previous trial (win-stay). After an incorrect response, the operator that was <u>not</u> used on the previous trial is to be used (lose-shift).

This model provides a method to maximize correct responding by the learner. It monitors performance, and its dynamic property makes it always try to do better. A change in parameter values results in changes in the content, organization and sequencing of instructional displays. This model changes parameter values so that the values tend to oscillate around an "ideal valve" for the individual where correct responding is maximized. The band of oscillation is made narrower by decreasing the value of θ in the operators as a function of number of trials (as n gets larger, θ gets smaller).

If . ~ of the parameter values were to be modified simultaneously, the changes could all be confounded and a few very salient parameters could mask inhibitory changes in other parameters. Thus, parameters must be modified at least somewhat independently of one another. Modifying one at a time provides independence, but optimization of instructional presentation would be incredibly slow. Thus, a sampling scheme must be used to allow a subset of parameters to be maniuplated simultaneously, but to constantly change the members in the subset so that confounding of changes is effectively eliminated.

Each instructional paradigm has many (more than 50 at this early stage in our thinking) parameters associated with it. The sampling scheme then calls for a few (say 5) of these parameters to be sampled whenever an objective requiring that paradigm is under consideration. The values of those five parameters are then modified in accordance with the above rules. If the learner response is correct, those modified five values are returned to the system, and another five parameters are selected for modification. If the learner response is incorrect, the same five parameters are remodified in accordance with the above rules. At all times sampling is done with replacement and with a consideration of the saliency (or relative importance) of each parameter. An estimate of the saliency value for each parameter can be derived either logically or empirically.

The instructional system requires that:

1.) All parameters must always have a value.

2.) A given parameter can have different values as it is associated with different paradigms.

3.) Parameter specifications necessitate nesting (it is meaningless to set voice volume if there is no oral component to the display) and eliminating some parameters from consideration at certain times.

The steps that the modification scheme goes through are presented in Table 2. It is hoped that these steps listed in the order of operation will help the listener to conceptualize the somewhat complex, but intuitive model presented here.

Quantitavely, this modification scheme is designed to: 1) Handle the potentially large number of parameters that it must. 2) Make observable changes as opposed to miniscule changes by changing one parameter at a time. 3) Optimize instructions. The operators function so as to maximize improvements while minimizing setbacks. 4) Attentuate the abruptness of changes as the system and the learner accommodate to each other. 5) Adapt to changes (learning or maturation) in the learner over time. This last property can be augmented by systematically letting θ become larger and then reduce again and by resetting saliency values over time.

Before this modification scheme can be incorporated into an instructional system and implemented for use, certain basic questions must be pursued. First, the relevant parameters must be identified and scaled. This problem is not insurmountable because only manageable parameters need to be used. Additional parameters can be added to the system as we discover them and learn how to work with them.

Experiments must be run to validate the modification scheme. Computer generated data could help demonstrate that this scheme leads to optimization of performance. However, subjects must also be taught in such a system. Different students should end up with different p values. If John is given Sally's p values, he should perform less well than with his own. If John is given Sally's p values, the values should change to resemble John's original set after some time on the system. These inferences suggest several experiments which are to be carried out. At the moment an evaluation of the entire cybernetic instructional system should be forthcoming. This evaluation will probably be mostly of a formative nature. That is, it will result in changes being made in the system rather than resulting in an over-all approval or disapproval of the system. Such data collection is currently only in the planning stages. Some of it must be gathered before any comments about the effectiveness of this modification scheme and of this approach to designing instructional situations can properly be made.

TABLE 1

OPERATORS FOR CHANGING PARAMETER VALUES

P= Value of a parameter of an instructional paradigm.

$P_{i,n}$ = Value of parameter "i" before learner response number "n".

Operator:

A $\quad P_{i,n+1} = (1 - \theta)\ P_{i,n} + \theta$

B $\quad P_{i,n+1} = (1-\theta)\ P_{i,n}$

TABLE 2

OUTLINE OF OPERATION OF MODIFICATION SCHEME

1.) The system provides a set of parameters whose values differ among individuals.

2.) Each instructional paradigm has a subset of parameters associated with it. (A parameter has a value in each of these subsets it appears).

3.) Take the subset for the paradigm associated with the objective under consideration.

4.) Establish which parameters are irrelevant to determining the display because of being nested below a parameter which has a present value that makes them superfluous.

5.) Exclude the currently irrelevant parameters from the subset and draw a set of five parameters. Selection considers the relative saliency of each parameter within the large subset.

6.) Operate * on each parameter in the set of five.

7.) Present the learning trial.

8.) Look at response correctness.

   a.) if correct, return the five parameter values and select a new set of five.

*Since the set of five is only returned after a correct response, the operator will be selected so as to move the value in the same direction as on the trial when that value was last manipulated.

Table 2 (continued)

b.) if correct, reoperate on each parameter (change direction) value in the set of five and go to next trial.

REFERENCES

Cronbach, L.J. How can instruction be adapted to individual differences? In R.M. Gagne (Ed.) _Learning and individual differences._ Columbus, Ohio: Merrill,1967.

Merrill, M.D. Components of a cybernetic instructional system. _Educational Technology._ April 15, 1968, pp. 5 - 10.

Merrill, M.D. _Educational psychology for instructional design._ In press (to be published by Lippincott early in 1969).